Dendrodrilus rubidus **System:** Terrestrial

Kingdom	Phylum	Class	Order	Family
Animalia	Annelida	Clitellata	Haplotaxida	Lumbricidae

Common name jumpers (English), trout worms (English), red wiggler worm (English), red trout worms (English), wigglers (English), pink worms (English), red wigglers (English), jumbo red worms (English), jumping red wigglers (English)

Synonym
Dendrobaena rubida
Allolobophora constrictus , (Rosa, 1884)
Allolobophora norvegicus , (Eisen, 1874)
Allolobophora tenuis , (Eisen, 1874)

Similar species

Summary Dendrodrilus rubidus is a small, litter dwelling earthworm native to Europe that has invaded areas of Australia, South America, Canada, Russian Federation United States and a large number of sub-Antarctic islands. The combined impacts of this species and other exotic earthworms are having profound effects on forest ecosystems in North America, particularly in regions which lack native earthworms. Exotic earthworms rapidly consume leaf litter, thereby altering nutrient cycling and availability and other soil properties. This has cascading effects on microbial communities, invertebrates, vertebrates and seedling establishment, and may alter entire plant communities and threaten rare plant species.

[view this species on IUCN Red List]

Species Description
Dendrodrilus rubidus is a small (< 10 cm) highly pigmented epigeic earthworm (Hendrix & Bohlen, 2002).

Notes
Four subspecies or morphs of *Dendrodrilus rubidus* are known: *rubidus* (Savigny, 1826) *tenuis* (Eisen, 1874), *norvegicus* (Eisen, 1874) and *subrubicundus* (Eisen, 1874) (Frenot, 1992).

Lifecycle Stages
Dendrodrilus rubidus cocoons are extremely cold tolerant, surviving temperatures lower than -40 °C. However the adult stage is unable to withstand even slightly negative temperatures. Thus only the cocoons overwinter in cold climates (Berman *et al*., 2010).

Uses
Dendrodrilus rubidus is used as a live bait by anglers, and is also used for vermicomposting (Keller *et al*., 2007). In agricultural systems and natural systems adapted to earthworms, they provide important ecological services including improvement of soil properties (e.g. ., nutrient turnover, soil structure and water flow, pH, functional biodiversity, food sources for vertebrate predators) and increasing plant production. Indeed earthworms have been deliberately introduced to pastures, landfills and reclaimed mite sites in several countries around the world to improve agricultural productivity and minimise soil degradation (Baker *et al*., 2006).

Habitat Description
Dendrodrilus rubidus is common in coniferous forests in its native European and introduced North American range (Addison, 2009). It is an epigeic species which inhabits and feeds in the litter and organically enriched surface layers of soil (about 0-10 cm depth) (Hendrix & Bohlen, 2002). It is acid-tolerant (Addison, 2009), and the cocoons are extremely cold tolerant, surviving temperatures lower than -40 °C. However the adult stage is unable to withstand even slightly negative temperatures. Thus only the cocoons overwinter in cold climates (Berman *et al*., 2010).
Troglophilic (cave-dwelling) behaviour has been observed in *D. rubidus* in Alabama, Georgia, South Carolina, Tennessee (Reeves *et al*., 1999) and in eastern Canada (McAlpine & Reynolds, 1977).

Reproduction
Dendrodrilus rubidus includes both sexual and parthenogenic morphs (Frenot, 1992).
Parthenogenic species are capable of rapid adaptation, as large numbers of offspring can be produced, some of which are likely to have beneficial mutations (Simon *et al*., 2002 in Cameron *et al*., 2008).

Nutrition
Dendrodrilus rubidus is an epigeic species. It inhabits and feeds in the litter and organically enriched surface layers of soil (about 0-10 cm depth). Epigeic species facilitate the breakdown and mineralisation of surface litter (Hendrix & Bohlen, 2002). Epigeic species tend to possess more cellulase enzymes than anecic or endogeic earthworms, reflecting their diet of relatively undecomposed organic matter (McLean *et al*., 2006).
Earthworms, especially *Lumbricus* species have high calcium demands and strong litter calcium preferences (Reich *et al*., 2005 in Holdsworth *et al*., 2008). Their high calcium demands may be necessary to supply their well developed calciferous glands, which produce cal¬cium carbonate that could moderate blood CO2 levels and pH when soil pCO2 levels are elevated (Holdsworth *et al*., 2008). Calcium content of litter is thus a predictor of litter preference among earthworms, and consequently decomposition rates and litter mass loss (Holdsworth, 2006 in Holdsworth *et al*. 2008).

General Impacts

In many ecosystems and in agricultural systems earthworms are highly beneficial to soil processes (Hendrix & Bohlen, 2002). However in forest ecosystems with few or no native earthworms, introduced species can have negative effects. Earthworms are keystone detritivores that can act as “ecosystem engineers” and have the potential to change fundamental soil properties, with cascading effects on ecosystem functioning and biodiversity (Frelich *et al*., 2006; Eisenhauer *et al*., 2007; Addison, 2009)

Exotic earthworms are a particular problem in previously earthworm-free temperate and boreal forests of North America dominated by *Acer*, *Quercus*, *Betula*, *Pinus* and *Populus* (Frelich *et al*., 2006).

Earthworms are often classified based on their activity and feeding type, which affects their impacts on the soil (Bouché, 1977 in Addison, 2009). *Dendrobaena octaedra* and *Dendrodrilus rubidus* are epigeic species, which inhabit and feed at the soil surface. Epigeics physically disrupt the organic layer of the soil by consuming and mixing the F and H layers, producing a homogenous and granular form of organic forest floor (Addison, 2009). *Lumbricus rubellus* operates in two categories, 1) epigeic which inhabit and feed at the soil surface and 2) endogeic which live and feed in the mineral horizons below the organic (LFH) layer. Thus it is considered epi-endogeic in its habits, feeding on organic matter in the forest floor, but also mixing the organic material into the upper layer of mineral soil (Addison, 2009). *L. terrestris* is a deep-burrowing anecic earthworm, which create permanent vertical burrows in the mineral layer. They come to the surface to feed on litter and pull it down to their burrows, depositing casts of mixed organic and mineral material on the soil surface (Addison, 2009).

Thus earthworms in different functional groups have different impacts on the soil (Frelich *et al*., 2006; Hale *et al*., 2008). Often multiple earthworm species inhabit areas of forest, and studies suggest that impacts are greater when earthworms from more than one functional group occur together (Hale *et al*., 2005; Hale *et al*., 2008). Earthworm invasions typically occur in waves (e.g. Hendrix & Bohlen, 2002; Eisenhauer *et al*., 2007), with epigeic (e.g. *D. octaedra*, *D. rubidus*) or epi-endogeic (e.g. *L. rubellus*) species arriving first as they are able to utilise undisturbed forest floors. The first noticeable impacts tend to be physical disruption of the stratified humus layers on the forest floor. Endogeics generally only invade after the organic layer has been modified by epigeic or epi-endogeic species. Anecic species (e.g. *L. terrestris*) are usually last to arrive (James & Hendrix, 2004 in Addison, 2009).

The purported impacts of invasive earthworms are often varied between publications, and different soil types and soil layers may be affected differently by earthworm invasion. However the main effect of earthworms is to consume litter, and incorporate it into deeper soil layers, thus causing mixing of the A and O soil horizons. This causes extreme reduction of the litter layer and changes in nutrient concentrations and cycling in the soil. Other soil characteristics such as pH, porosity and decomposition rates may also be affected. Physical disruption of plant roots and mycorrhizal associations is also a common impact. These changes to fundamental soil properties have cascading effects on plant communities, microorganisms, micro and mesofauna, birds and mammals (Hale *et al*., 2008; Addison, 2009).

For a detailed account of the impacts of invasive earthworms please read Earthworms Impacts Information.

Management Info
There are currently no effective methods to eradicate established earthworm populations without unacceptable non-target effects. Thus the main technique for managing invasions is prevention of introductions, via various pathways (Cameron *et al*., 2007; Keller *et al*., 2007).
Preventative measures: One of the major pathways for earthworm introductions is believed to from release by anglers discarding unwanted live bait. Keller *et al*. (2007) suggest two alternatives to reduce the likelihood of further establishments while preserving the economically important live trade of earthworms. These are: 1) Replace the species currently sold with earthworm species that are unlikely to establish populations, e.g. *Eudrilus eugeniae* which has an extremely low invasion risk in the U.S. Midwest, and 2) Strengthen efforts to educate anglers to dispose of live earthworms responsibly, i.e. in the trash where landfill conditions are likely to kill them (Keller *et al*., 2007) or to prohibit the abandonment of live bait (Cameron *et al*., 2007).
Similarly, transport of cocoons and earthworms via vehicular transport is a major pathway for introduction to new locations. Thus construction of fewer roads, restricting the amount of traffic on roads or reclaiming roads where possible would minimize spread of earthworms (Cameron & Bayne, 2009).
Management and regulatory strategies should also take into account the fact that some earthworm species, such as *Lumbricus rubellus* have larger impacts than others. This species is less widely distributed than other exotic species. Thus preventing its introduction to new areas is important, even if those areas are already infested with other species (Hale *et al*., 2006). Similarly, some forests will be more susceptible to invasion than others. Litter calcium content is likely to be an important predictor of litter decomposition rates by exotic earthworms (Holdsworth, 2008).
Callaham *et al*. (2006) suggest various policy measures that could be adapted to prevent the spread of exotic earthworms. The authors suggest restrictions on transportation of soils from infested areas to non-infested areas, unless a special permit certifying that the material is free from earthworm propagules has been granted. Formalized earthworm introduction decision making tools are also recommended as an alternative to the *ad hoc* decisions made by regulating agencies at present. This decision-making process allows for the quarantine of materials containing propagules of earthworms that have not been identified or widely introduced previously. These quarantines would provide time to determine the ecological risk posed by the introduction of a given earthworm species into particular systems. Suggested types of information needed to determine ecological risk include mode of reproduction, number of embryos per cocoon, ecological “strategy”, and temperature, pH and moisture requirements (Callaham *et al*., 2006).
Cultural measures: Successful establishment of earthworm populations is influenced by management of the site. For example, synergistic effects of the invasive weed buckthorn and exotic earthworms could be minimized by early control measures to limit the weed (Heneghan *et al*, 2006).
Chemical control: Where non-native earthworms are not well established or are found in discrete populations, the use of chemical treatments to eradicate undesirable worms may be successful. Chemical control have been used in the management of golf courses. While these treatments are highly effective, the non-target effects of chemicals should be examined before large-scale utilization (Callaham *et al*., 2006).

Pathway
When Europeans first colonized the United States midwest they probably brought earthworms as adults or cocoons in dry ship ballast (Hendrix & Bohlen, 2002).Road vehicles are thought to be a major vector for the spread of earthworm cocoons (Cameron *et al*., 2008). Epigeic species are more easily transported in this manner as they are present close the litter surface (Cameron *et al*., 2007). In fact Cameron & Bayne (2009) found that the probability of earthworm occurrence and extent of spread increased as road age increased in Alberta.

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ALIEN RANGE

[1] ARGENTINA
[2] AUSTRALIA
[11] CANADA
[1] CHILE
[1] FALKLAND ISLANDS (MALVINAS)
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[4] FRENCH SOUTHERN TERRITORIES
[1] GEORGIA
[1] GREAT LAKES
[1] HEARD ISLAND AND MCDONALD ISLANDS
[1] JAPAN
[2] NEW ZEALAND
[1] QATAR
[2] RUSSIAN FEDERATION
[3] SAINT HELENA
[1] SOUTH AFRICA
[16] UNITED STATES
[1] VENEZUELA

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